

# 13. LIGHTING

## 13.1 VISION

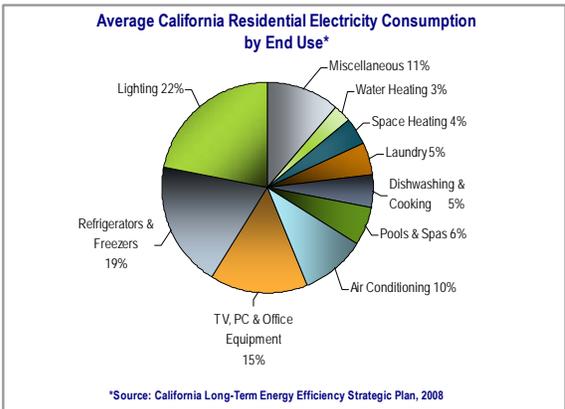
**BY 2020, ADVANCED PRODUCTS AND BEST PRACTICES WILL TRANSFORM THE CALIFORNIA LIGHTING MARKET. THIS TRANSFORMATION WILL ACHIEVE A 60-80 PERCENT REDUCTION IN STATEWIDE ELECTRICAL LIGHTING ENERGY CONSUMPTION BY DELIVERING ADVANCED LIGHTING SYSTEMS TO ALL BUILDINGS.**

## 13.2 PROFILE

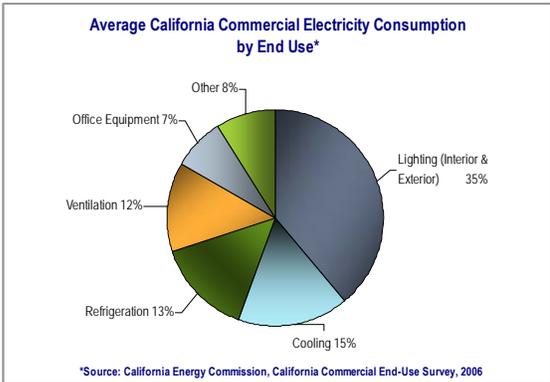
Lighting comprises approximately one-fourth of California’s electricity use;<sup>1</sup> therefore, the widespread use of energy efficient lighting is a critical element in the Strategic Plan. California’s AB 1109 (known as “the Huffman Bill”<sup>\*</sup>) will phase-out traditional, low efficiency incandescent lamps by 2018 and help advance the Strategic Plan’s goals. However, supporting strategies and implementation activities are needed to achieve the higher goal of a 60 to 80 percent reduction in energy usage for lighting.

Each goal in this chapter has elements relevant to three market sectors: residential, nonresidential and exterior lighting.

*Residential.* Lighting comprises 22 percent of electricity use in the average California home (see figure).<sup>2</sup> With more than 11 million homes and 500 million light sockets in California, there is substantial potential for energy savings and peak demand reduction.<sup>3</sup> For example, incandescent lamps in the 10-15 lumens per watt range are the predominant technology in residential applications. Switching all residential sector lighting to technologies using 40 lumens per watt would achieve a 50 percent reduction in energy use.<sup>4</sup>



*Non-Residential.* Nonresidential lighting covers a wide range of applications including task lights on office desks and overhead lighting in industrial warehouses.<sup>5</sup> In the commercial sector, lighting accounts for approximately 35 percent of electricity use (see figure below).



\* See Glossary at end of document for definitions of terms with asterisk.

California has 1 billion square feet of commercial office space, most of which was built prior to the state's Title 24\* regulations. Installing existing best practice\* lighting retrofits in these applications (instead of simple ballast and lamp replacements) will yield substantial savings<sup>6</sup> and can enhance worker productivity by improving the visual environment. Products for office task ambient lighting systems can save 40-60 percent over current practices — approximately twice the energy, peak demand and CO<sub>2</sub> emissions compared to current Title 24 codes of 0.9 watts per square foot.<sup>7</sup>

*Commercial office spaces typically rely on a standard practice\* lighting design approach known as “general lighting,” where ceiling-mounted lights supply uniform lighting levels for an entire office interior. This approach results in wasted energy, increased cooling costs and sub-par lighting for human performance. Best practices include a high performance task lighting retrofit in worker specific areas, reducing lighting energy use and increasing the quality of light in the office space.*

*Exterior.* Exterior lighting includes parking lot, area, walkway and security lighting. In the nonresidential sector, exterior lighting usage comprises 1.4 percent of California's total electricity use, much of which occurs during limited occupancy periods.<sup>8</sup> Through a combination of sensors, occupancy controls and

other technologies, end users can save money by reducing energy usage by more than 50 percent.<sup>9</sup> Such retrofits are one of many relatively untapped opportunities to reduce lighting energy demand and deliver identical or improved service.<sup>10</sup>

Substantial reductions in lighting energy demand are contingent upon successfully addressing or navigating around barriers within the lighting market. These impediments include:

- **Policy Barriers** that conflict with the accelerated adoption of best practice lighting technologies and systems required to meet the state's ZNE goals;
- **Lack of knowledge** regarding best practice lighting technologies among specifiers, installers and other lighting professionals;
- **Proprietary protocols** that can limit innovation and interoperability of lighting systems and integration with other building and network systems;
- **Lack of retailer and consumer awareness** about lighting's invisible benefits, such as contributions to human performance, well-being and energy and cost savings;
- **Cost** constraints, including the challenge of encouraging end users to purchase and install best practice lighting technologies and systems;
- **Gaps in the Research, Development and Demonstration (RD&D)\* infrastructure** that cause redundancies and unnecessary delays in rapid deployment of best practice technologies to the market.

## 13.3 GOALS

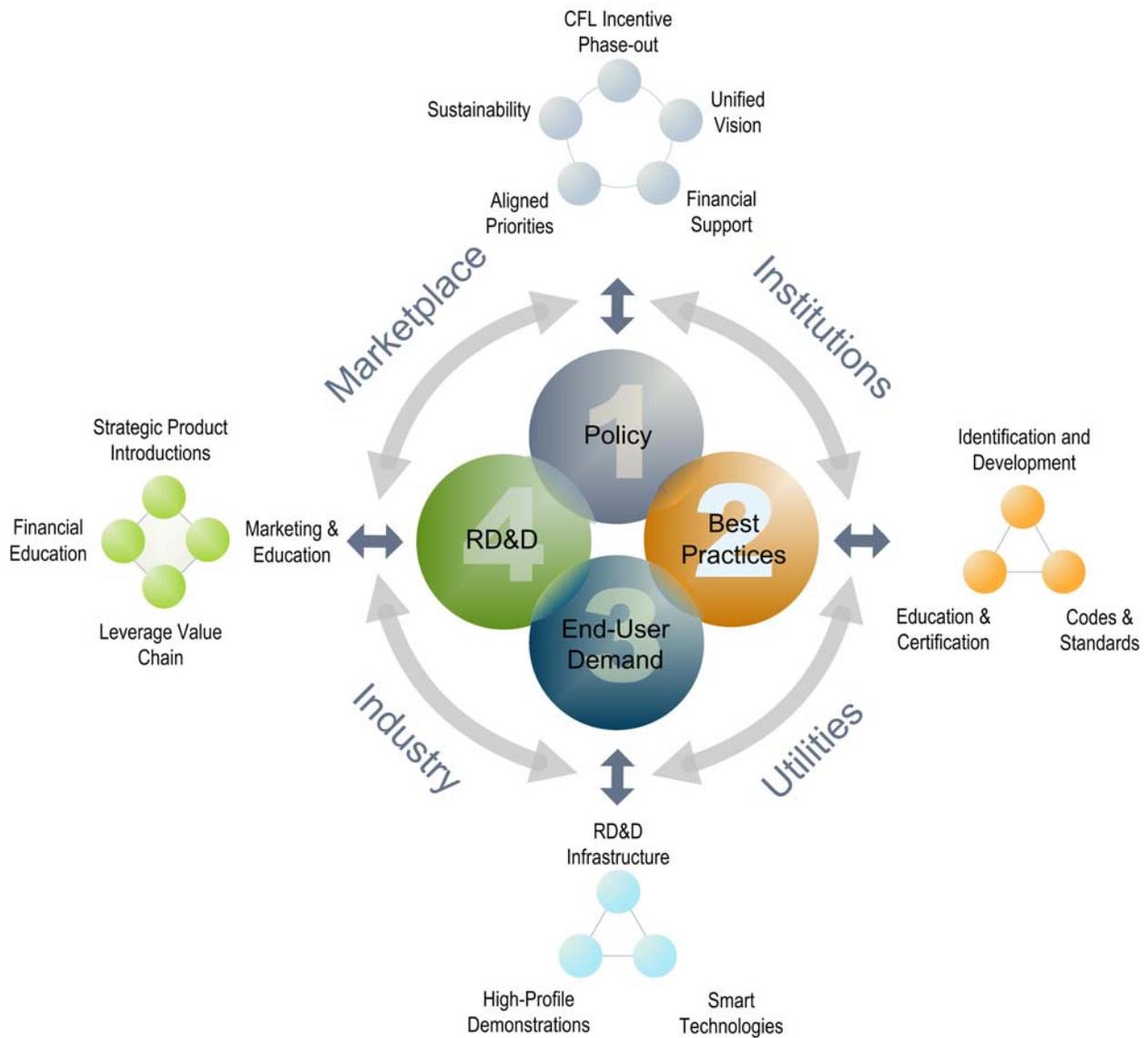
Goal	Goal Result
1. Develop and implement coordinated policies, procedures, and other market interventions that eliminate barriers, accelerate lighting market transformation* in California and provide incentives for best practice lighting technologies and systems.	 By 2020, existing policies and procedures in California will enable lighting technologies to contribute to zero net energy (ZNE)* consumption with negligible negative impacts on the environment.
2. Define and advance best practices for design, installation, operation and maintenance of integrated systems* to achieve sustainable* lighting solutions for all spaces.	 By 2020, 100% of new and retrofit lighting installations will meet best practices. End users will receive education and training to maintain optimal performance of installations throughout their useful lives.
3. Create widespread end user demand to purchase and use best practice lighting technologies and systems.	 By 2020, transform consumers' lighting preferences to best practices as demonstrated by an 80% decrease in perceived barriers to adoption and a 50% decrease in sales of inefficient lighting products in key market segments (over 2010 baselines).
4. Develop research, development and demonstration (RD&D) networks to create, test, and deliver the lighting solutions needed to transform California's lighting market achieve ZNE goals.	 Create a broad RD&D portfolio of technologies that will support a 60-80% statewide reduction in electrical lighting energy consumption by 2020.

The goals described in this chapter envision defining, creating, testing and delivering advanced lighting products and best practices to an educated pool of end users in a supportive policy environment. Best practices are defined as coordinated technologies, systems and design approaches that typically provide savings of 25-50 percent over standard practices while avoiding negative environmental impacts. Best practices may change over time as improved components, technologies and design approaches become available. The four goals in this chapter together provide the foundational support for best practices to make them the default lighting choice for California end users.

In California, lighting technology, design and installation is regulated primarily by the California Energy Commission's (CEC) Title 20\* and Title 24 appliance and building codes (as

well as by the Federal Energy Policy Act\*). Such command and control measures — including local government reach codes\* — can advance lighting market transformation but cannot achieve the goals without interventions that bring advanced lighting technologies and best practices to the marketplace and support rapid adoption by end users.

As shown in the figure below, this chapter sets forth a comprehensive strategy to bring together all aspects of the lighting market in California: public policy and regulations, building designers, owners, managers and occupants, consumers and technology developers. This chapter will set the market on the path to achieve the targeted 60-80 percent reduction in statewide lighting electrical use thereby furthering the goal of ZNE buildings in California.



The figure above represents the interconnectedness of the four lighting goals. To achieve the vision for a transformed lighting market in California, all four goals have to work in synergy to continuously define, create, test and deliver advanced lighting products and best practices to an educated pool of end users in a supportive policy environment.

## 13.4 STRATEGIES

California can achieve a 60-80 percent reduction in statewide lighting energy use by 2020. The Huffman Bill requires California to “reduce average statewide electrical energy consumption by not less than 50 percent from the 2007 levels for indoor residential lighting and not less than 25 percent from the 2007 levels for

indoor commercial and outdoor lighting by 2018.” This critical piece of legislation will move California toward its goals but will not achieve the 60-80 percent reduction in lighting energy consumption necessary to truly transform the lighting market.

Advanced lighting technologies\* and design solutions – such as integrated controls, daylighting\* and task/ambient lighting systems – can deliver the additional savings necessary to achieve this transformation.<sup>11, 12</sup> This will require shifting incentives to encourage best practices, enhancing coordination among regulatory agencies and creating more effective financing mechanisms for lighting retrofits.

To effect rapid change in California's lighting market, numerous stakeholders — beyond the CPUC and IOUs — will need to participate actively and collaborate effectively. With a vast array of players involved in the lighting market — such as the CEC's Public Interest Energy

Research (PIER) Program\*, manufacturers, distributors, retailers, Title 24 consultants, specifiers and contractors, lighting designers, architects, environmental groups, construction companies, building engineers, industry and professional groups, utilities, local building officials, building owners/managers, consumers and local, state and federal government agencies — it is essential that the industry's leaders continue their involvement past the development of these goals and strategies and help implement the actions needed for the next 10 years and that new leaders continue to become engaged as the process moves forward.

## IMPLEMENTATION PLAN

**Goal 1: Develop and implement coordinated policies, procedures, and other market interventions that eliminate barriers, accelerate lighting market transformation in California and provide incentives for best practice lighting technologies and systems.**

There are many untapped lighting efficiency opportunities that could yield significant energy savings in California if comprehensive and innovative policies are implemented. Policy can both directly and indirectly affect availability and the use of best practice technologies. California's major policy-making institutions — including the CPUC, CEC, Air Resources Board (ARB)\* and local governments\* — must commit to integrated policies that transform California's lighting market away from standard practices to best practices at a rapid pace.

To date, the majority of the utilities' lighting programs have focused on widget swap-out strategies (such as replacing incandescent lamps with CFLs). With the new state and federal lighting standards, utility programs promoting basic CFLs will provide little incremental benefit.<sup>13</sup> Future efforts in lighting, including ratepayer funded programs, should focus on systems-based opportunities that achieve savings beyond standards. This may require reexamining the CPUC's current 3-year funding cycle to potentially allow longer-term funding and targets.

California's key regulatory agencies must coordinate on intermediate steps toward lighting market transformation and ZNE policies and for

improvements to codes and standards. In addition, by creating economies of scale and emphasizing lighting in the state's ongoing greening efforts, governments at the state, regional and local levels can help reduce initial market barriers through leadership by example.

To transform the market, policymakers must help end users afford or finance best practice lighting solutions. Additional financial mechanisms to address market barriers must also be created to spur adoption. Related solutions — such as incorporating third-party funding into large scale on-bill financing programs and advancing statewide participation in AB 811\*-authorized financing mechanisms - could enable a broader base of Californians to purchase and install best practice lighting technologies. California should examine ways to align incentives such that lighting efficiency is maximized prior to awarding incentives for onsite generation (e.g., California Solar Initiative).

Policies should be developed to ensure that best practice lighting systems avoid unintended negative environmental consequences by minimizing the ecological impacts of each technology throughout its lifecycle — from design through disposal. California must support

a comprehensive view of energy efficient lighting systems that includes not only their energy

savings and financial implications but also their environmental costs.

The strategies to achieve this goal include:

- **Aligned Priorities:** Match public policy and utility energy efficiency program priorities to statewide lighting goals.
- **Unified Vision:** Build a common vision among key state regulators and align codes and standards to advance California’s lighting market transformation.
- **Financial Support:** Create financial incentives and supportive policies to avoid trapped lighting energy savings opportunities.
- **Sustainability:** Minimize environmental impacts of each lighting technology throughout its lifecycle (production, use and disposal).
- **Basic CFL Incentive Phase-out:** Prepare suppliers for a shift in program incentives away from CFLs and toward the next generation of high efficiency lighting.

### Goal 1: Policy for Transformation

Implementation Plan and Timeline			
Strategies	Near Term 2010 – 2012	Mid Term 2013 – 2015	Long Term 2016 – 2020
1-1: Match state laws, policy and regulations with utility energy efficiency program priorities and statewide lighting goals.	<ul style="list-style-type: none"> <li>• Explore implications of current cost/benefit methodologies on IOUs’ ability to incorporate advanced lighting products into their programs</li> <li>• Explore implications of IOU program cycles on ability to reach lighting goals</li> <li>• Monitor lighting legislation, regulations and industry developments with the aim of incorporating additional lighting technologies and best practices into the next utility program cycle (including residential low-income)</li> <li>• Design and test innovative program delivery strategies to accelerate market transformation</li> <li>• Incorporate 2010-2012 EM&amp;V results into policies and programs for future EE program cycles</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust methods as appropriate</li> <li>• Adjust cycles as appropriate</li> <li>• Continue monitoring legislation, regulations and industry developments; incorporate new technologies and best practices into the next utility program cycle</li> <li>• Incorporate cost-effective pilot programs from prior program period into core programs; continue pilot projects</li> <li>• Ongoing</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust methods as appropriate</li> <li>• Adjust cycles as appropriate</li> <li>• Ongoing</li> <li>• Incorporate cost-effective pilot programs from prior program period into core programs; continue pilots</li> <li>• Ongoing</li> </ul>

**Implementation Plan and Timeline**

Strategies	Near Term 2010 – 2012	Mid Term 2013 – 2015	Long Term 2016 – 2020
<p><b>1-2:</b> Build a common vision for advancing lighting market transformation among key state agencies.</p>	<ul style="list-style-type: none"> <li>Engage statewide institutional stakeholders in collaborative efforts to agree on steps toward lighting market transformation and ZNE goals</li> <li>Align lighting-related codes &amp; standards, green building rating systems and industry norms and practices with ZNE policy</li> <li>Develop standards for all public buildings to encourage leadership by example in support of ZNE goals</li> </ul>	<ul style="list-style-type: none"> <li>Review and revise steps as needed</li> <li>Identify and resolve next priorities</li> <li>Implement ZNE standards in public buildings</li> </ul>	<ul style="list-style-type: none"> <li>Review and revise steps as needed</li> <li>Identify and resolve next priorities</li> <li>Ongoing</li> </ul>
<p><b>1-3:</b> Create financial incentives and supportive policies to avoid trapped lighting energy savings opportunities and make best practice lighting solutions affordable.</p>	<ul style="list-style-type: none"> <li>Identify and implement creative financing mechanisms, including those that reduce barriers to lifecycle investment strategies</li> <li>Identify and eliminate barriers to on-bill financing and incorporate third-party financing into IOU program offerings</li> <li>Target statewide participation in AB 811-authorized financing mechanisms (such as Property Assessed Clean Energy* [PACE] bonds), to the extent that these programs are available</li> <li>Advocate to raise percentage above T24 (including lighting) required to receive funding from California Solar Initiative (CSI) to 30%</li> <li>Increasingly integrate funding for demand response*, energy efficiency and renewable energy projects</li> </ul>	<ul style="list-style-type: none"> <li>Increase the adoption rate of lifecycle investment strategies</li> <li>Expand on-bill financing program</li> <li>Ongoing</li> <li>Advocate for 60% above T24 to obtain CSI incentives</li> <li>Ongoing</li> </ul>	<ul style="list-style-type: none"> <li>Increase the adoption rate of lifecycle investment strategies</li> <li>Expand on-bill financing program</li> <li>Ongoing</li> <li>Advocate for 90% above T24 to obtain CSI incentives</li> <li>Ongoing</li> </ul>

### Implementation Plan and Timeline

Strategies	Near Term 2010 – 2012	Mid Term 2013 – 2015	Long Term 2016 – 2020
<p><b>1-4:</b> Minimize environmental impacts of each lighting technology throughout its lifecycle (production, use and disposal).</p>	<ul style="list-style-type: none"> <li>• Allocate RD&amp;D funding to increase sustainability of best practice lighting systems and determine long range funding needs</li> <li>• Develop cost-effective, convenient methods to collect and recycle any end of life lamps and test as pilot programs</li> <li>• Establish hazardous materials content specifications for all lighting products in IOU programs</li> <li>• Develop and implement voluntary manufacturing and labeling standards that include sustainability indices</li> <li>• Incorporate measurement of avoided GHG emissions along with kW/kWh into EM&amp;V activities/reports to encourage deeper energy savings</li> </ul>	<ul style="list-style-type: none"> <li>• Develop and implement funding plan</li> <li>• Continue successful recycling programs</li> <li>• Implement specifications</li> <li>• Develop and implement additional standards and continue recruiting manufacturers to participate</li> <li>• Refine and continue GHG efforts</li> </ul>	<ul style="list-style-type: none"> <li>• Expand funding, based on results of prior cycles</li> <li>• Ongoing</li> <li>• Ongoing</li> <li>• Continue implementing standards and recruiting lighting manufacturers to participate in standards</li> <li>• Refine and continue GHG efforts</li> </ul>
<p><b>1-5 Coordinate phase out of Utility incentives for purchase of CFLs.</b></p>	<ul style="list-style-type: none"> <li>• Ensure that big box and home improvement retailers such as Wal-Mart and Home Depot are ready to stock Energy star price discounted CFLs in CA as IOUs phase out CFL programs</li> <li>• Utilities engage in negotiations with manufacturers and retailers to buy-down prices and stock the next generation of high efficiency lighting</li> </ul>	<ul style="list-style-type: none"> <li>• Ongoing</li> </ul>	<ul style="list-style-type: none"> <li>• Complete</li> </ul>

**Goal 2: Define and advance best practices for design, installation, operation and maintenance of integrated systems to include commissioning and tuning to achieve sustainable lighting solutions for all spaces.**

Whole building design is a key element of the Strategic Plan, and best practice lighting systems are a foundational component of whole building design strategy. Best practice lighting technologies, systems and solutions must become standard practice.

**Sample Best Practices in Lighting (2010)**

- *Task/Ambient Lighting with Controls in Commercial Offices*
- *Integrated Classroom Lighting Systems*
- *Interior Electronic High-Intensity Discharge (HID) lamps and ballasts*
- *Light-Emitting Diode (LED) Downlights for Residential Buildings*
- *Light-Emitting Diode (LED) Downlights for Commercial Buildings*
- *Smart Bi-level Exterior Lighting*

It is the nature of best practices to evolve; best practice lighting must be defined, updated frequently and promulgated to achieve the largest energy savings possible.<sup>†</sup> Identifying successive generations of lighting best practices must be part of RD&D efforts and pilot projects. These technologies and systems should be demonstrated and pilot tested, and post-occupancy data should be collected to optimize performance and improve energy savings estimates and ensure consumer acceptance. Incentives should be provided to California's major lighting end users should be to encourage benchmarking of energy lighting use over time to enable quantification and tracking of lifecycle impacts of these enhanced codes and building performance improvements.

Best practices should then be incorporated into utility programs and into pattern books\* to assist lighting professionals in improving the quality and efficiency of lighting statewide.

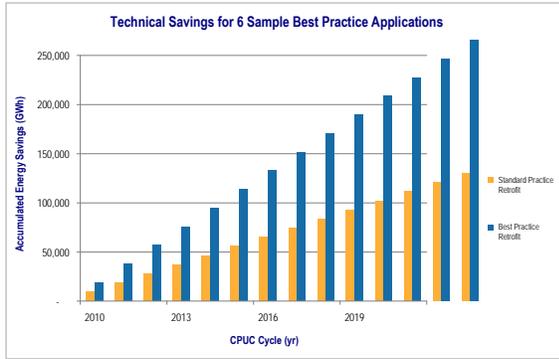
<sup>†</sup> As will be discussed under Goal 4 (RD&D), the CPUC will convene an advisory body to coordinate research and related activities with stakeholders. This body will define best practices for lighting and update these definitions annually as lighting technologies and systems evolve.

Lighting professionals must be trained and certified in the proper specification, installation and maintenance of the most up-to-date best practice technologies and systems. Certified lighting professionals must become the norm; contractors and electricians must be encouraged to obtain lighting certifications, trained to integrate efficient technologies and designs into lighting systems for both new construction and retrofit applications, and rewarded for doing so.

End users must be educated regarding the long-term benefits of best practice technologies to move the market away from decisions based upon first cost\* and simple payback\* (the amount of money spent on purchase/installation and amount of time to recover those costs) and toward lifecycle cost\* assessments.

In parallel, best practices must also be incorporated into building codes and standards to ensure their widespread adoption. The current multi-year cycle for updating California's building codes (including Title 20 and Title 24) is too slow to enable the ongoing and rapid adoption of advanced lighting technologies and systems into code. The current process for changing these codes should be examined to identify opportunities to streamline and integrate best solutions on an ongoing basis.

Strategies to achieve best practices must be tailored to major space types and customer segments. For example, low-income customers in particular have cost constraints that may place some advanced technologies and best practices out of reach. While these customers may not be on the leading edge of market transformation, strategies must be developed to make advanced technologies and best practices available to all market segments -- and continually move the market forward.



*This figure illustrates the technical potential energy savings achievable through the pursuit of six example best practices for lighting. The difference between the bars represents the “lost opportunity” inherent in the pursuit of standard practices in lighting efficiency. See Appendix A for the savings assumptions underlying these analyses.*

The key strategies to identifying, promoting and ensuring best practices include:

- **Identification and Development:** Identify best practices and continually update in coordination with lighting market transformation activities.
- **Education and Certification:** Elevate the level of professional practice and performance by expanding access to high-quality new and existing education, training and certification programs.
- **Codes and Standards:** Include lighting system design improvements in codes and standards and local government reach codes.

## Goal 2: Lighting Best Practices

Implementation Plan and Timeline			
Strategies	Near Term 2010 – 2012	Mid Term 2013-2015	Long Term 2016 – 2020
<p><b>2-1:</b> Identify best practices in coordination with RD&amp;D and lighting market transformation programs to ensure use of high-performance lighting systems.</p>	<ul style="list-style-type: none"> <li>• Identify top best practices for major space types and customer segments (including residential low income); achieve 50% of the potential savings identified</li> <li>• Develop online pattern books for market segments that represent at least 60% of the total lighting use</li> <li>• Develop pilot projects that support best practices</li> <li>• Initiate post-occupancy evaluation of 5% of permitted and/or incentivized lighting installations</li> <li>• Integrate best practices with core utility programs and ensure use in at least 50% of new projects</li> <li>• Incorporate open source lighting communications protocols into best practices, incentives and codes</li> <li>• Establish integration protocols for lighting systems with all building systems, smart grid, monitoring and commissioning systems used in the public sector</li> </ul>	<ul style="list-style-type: none"> <li>• Achieve at least 80% of the savings potential by switching to best practices</li> <li>• Add pattern books to cover at least 85% of total lighting use</li> <li>• Ongoing</li> <li>• Adjust the percent surveyed, based on 2010-2012 results</li> <li>• Ensure best practices are used in at least 80% of new projects</li> <li>• Include protocols for smart grid and building systems for lighting</li> <li>• Extend integration to 50% of private sector</li> </ul>	<ul style="list-style-type: none"> <li>• Achieve 95%+ of the potential savings identified by switching to best practices</li> <li>• Add pattern books to cover at least 95% of total lighting use</li> <li>• Ongoing</li> <li>• Confirm monitoring capability built into lighting systems</li> <li>• Ensure best practices are used in 95% of new projects</li> <li>• Include protocols for zero net energy systems for lighting integration</li> <li>• Extend integration to 100% of private sector</li> </ul>
<p><b>2-2:</b> Elevate the level of professional practice and performance for designers, architectural consultants, electrical contractors, engineers and other lighting professionals.</p>	<ul style="list-style-type: none"> <li>• Develop specifications for 2020 lighting best practices by market sector for highest end-uses in coordination w/RD&amp;D</li> <li>• Educate and train lighting professionals on evolving best practices and how best to explain their benefits to end users</li> <li>• Require Lighting Certification for designers and contractors who implement public agency installations/retrofits; encourage 30% of private sector projects to require certification</li> <li>• Ensure understanding and application of lighting system integration protocols among lighting professionals</li> </ul>	<ul style="list-style-type: none"> <li>• Expand 2020 specifications to 50% of all markets</li> <li>• Ongoing</li> <li>• Expand system to 50% of private sector projects</li> <li>• Ongoing</li> </ul>	<ul style="list-style-type: none"> <li>• Expand 2020 specifications to 100% of all markets</li> <li>• Ongoing</li> <li>• Expand system to 100% of private sector projects</li> <li>• Ongoing</li> </ul>

### Implementation Plan and Timeline

Strategies	Near Term 2010 – 2012	Mid Term 2013-2015	Long Term 2016 – 2020
<p><b>2-3:</b> Continuously promote lighting system design improvements to codes and standards based on the best available field data and studies.</p>	<ul style="list-style-type: none"> <li>• Explore opportunities to enhance and accelerate process for integrating best practices into codes (T20 and T24) and code enforcement</li> <li>• Develop an integrated benchmarking process that enables accounting of lighting savings and encourage 50% of California's major lighting end users to benchmark</li> <li>• Create a standard lifecycle evaluation for lighting impacts, including savings calculation template with kW; kWh, Therms, CO<sub>2</sub> and funding source</li> </ul>	<ul style="list-style-type: none"> <li>• Enhance process for integrating best practices into codes (including enforcement)</li> <li>• Optimize the integrated process to cover 80% of major markets</li> <li>• Ongoing</li> </ul>	<ul style="list-style-type: none"> <li>• Continue process for integrating best practices into codes (including enforcement)</li> <li>• Optimize integrated process for 100% of all markets</li> <li>• Ongoing</li> </ul>

### Goal 3: Create widespread end user demand to purchase and use best practice lighting technologies and systems.

Understanding the end user — e.g., CEOs, facility managers, individuals and apartment managers — is a prerequisite for effective product development and adoption of lighting best practices.

Influencing complex human choices (including product selection and use) for lighting is a significant challenge and cannot be accomplished simply by offering a better product. Recent studies published by the CPUC conclude that awareness of energy savings benefits alone does not lead to changes in attitudes, beliefs, habits and/or practices.<sup>14</sup> Barriers (perceived or actual) have an equal impact on adoption of energy efficient activity.

*California has some successful lighting market transformation experiences. For example, in the commercial sector, a combination of codes and standards, education and aggressive utility program promotions reduced new construction office lighting power density by 70 percent between 1973 and 2005 (from 4 watts to 1.2 watts per square foot).<sup>15</sup> In the residential market, CFLs have achieved saturation in approximately 20 percent of sockets.<sup>16</sup>*

The general public must be treated as a partner in lighting market transformation; consumers must understand, purchase, install and properly use energy efficient lighting. Consumer demand for advanced lighting will also change as end users develop lighting literacy (through education from schools or local governments) and understand how quality of light affects quality of life (health and performance).

Marketing to end users must leverage the most relevant outlets and influencers in the value chain to influence lighting decisions and purchases. This may include working with IOU customer service teams at points of change (i.e., lease renewals), manufacturers on improved labeling, trade unions on best installation practices, retailers on point-of-sale promotions

or even corporate “green teams”\* on bottom-up approaches to large scale corporate lighting upgrades. Relevant marketing messages should be developed for each market segment (including residential low income customers) based upon the specific barriers and motivations within each segment.

The higher first cost of best practice lighting technologies presents a challenge in consumer adoption. Communication strategies must be developed to encourage consumers to look past first cost through promotion of lifecycle costing and non-energy benefits such as reduced maintenance and improved comfort. For large scale installations, financing programs such as regional incentive guides, outreach partnerships with lenders and facilitating group purchases with public institutions must be explored. A transformed lighting market will require diverse financial options built upon understanding end users and the unique barriers facing each segment of the market.

Market transformation also requires the support of the lighting industry. In this highly competitive industry, data that can accelerate market transformation is not often shared. Annual baseline studies and market segmentation analyses should be conducted, widely shared among all market actors and utilized to create effective product introduction and marketing campaigns.

Strategic product introduction cannot be overemphasized. California must examine the success and failure of past market introductions (both inside and outside the lighting industry) to develop highly effective methods. Market introductions require the support of integrated communication strategies with market stakeholders (including advertising, marketing and public relations organizations) to convey how lighting affects the human environment and trigger end user desire for best practice lighting technologies and systems.

Specific activities to create widespread end user adoption of lighting best practices include:

- **Marketing and Education:** Transform thinking about lighting; teach Californians to equate quality of light with quality of life.
- **Leverage Value Chain:** Partner with key market actors to promote advanced lighting technologies and achieve maximum energy savings.
- **Financial Education:** Promote financing that enables a broad range of end users to purchase, install and maintain advanced lighting technologies.
- **Strategic Product Introductions:** Strategically introduce next generation products and technologies to the marketplace with progressive goals.

### Goal 3: Drive End User Demand

Implementation Plan and Timeline			
Strategy	Near Term 2010 – 2012	Mid Term 2013 –2015	Long Term 2016 –2020
<b>3-1:</b> Educate Californians to equate quality of light with quality of life.	<ul style="list-style-type: none"> <li>• Institute a statewide baseline study to assess end user wants and needs related to lighting as well as their satisfaction with current lighting technologies and systems</li> <li>• Create relevant campaigns and messages for each market segment (including residential low income)</li> <li>• Initiate lighting literacy education to the public via local governments, schools, etc.</li> <li>• Explore options for marketing campaigns targeting key outlets (including social media, retail displays, lighting shows, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>• Re-evaluate study; share results</li> <li>• Assess campaigns; use results to inform next phase</li> <li>• Coordinate with K-12 schools to introduce lighting literacy to curriculum</li> <li>• Assess and refine campaigns</li> </ul>	<ul style="list-style-type: none"> <li>• Re-evaluate study; share results</li> <li>• Assess campaigns; use results to inform next phase</li> <li>• Coordinate with elementary schools to introduce lighting literacy to curriculum</li> <li>• Assess and refine campaigns</li> </ul>
<b>3-2:</b> Leverage key market stakeholders along the entire lighting value chain to promote advanced lighting technologies, systems and best practices.	<ul style="list-style-type: none"> <li>• Develop partnerships with lighting influencers to coordinate promotion of priority technologies</li> <li>• Work with IOUs to leverage customer service teams and ensure efficient lamps are installed, not stored</li> <li>• Launch grassroots efforts with corporate green teams and local environmental groups to influence lighting leadership</li> <li>• Elevate the role of lighting in green building rating systems (e.g., LEED)</li> <li>• Work with industry on tenant improvement packages (link to high-quality advanced lighting)</li> </ul>	<ul style="list-style-type: none"> <li>• Develop and distribute partnership case studies/demonstration projects</li> <li>• Leverage contractors to help educate public about advanced lighting</li> <li>• Ongoing</li> <li>• Institutionalize changes; maintain and ongoing feedback loops</li> <li>• Develop statewide initiatives to incorporate best practices into retrofit and new construction projects</li> </ul>	<ul style="list-style-type: none"> <li>• Ongoing</li> <li>• Develop lead sharing programs for all lighting influencers</li> <li>• Ongoing</li> <li>• Ongoing</li> <li>• Ongoing</li> </ul>

### Implementation Plan and Timeline

Strategy	Near Term 2010 – 2012	Mid Term 2013 –2015	Long Term 2016 –2020
<p><b>3-3:</b> Educate decision makers about creative financial mechanisms that enable purchase of advanced lighting technologies, systems and best practices.</p>	<ul style="list-style-type: none"> <li>• Explore barriers to sale/purchase/installation of best practice lighting technologies</li> <li>• Create and publicize cooperative financing guides that inventory all financing options related to best practice lighting solutions</li> <li>• Create education and outreach partnerships with lenders focused on financing energy efficient lighting projects</li> <li>• Facilitate group purchasing orders for large institutions</li> </ul>	<ul style="list-style-type: none"> <li>• With RD&amp;D and policy advisors, reassess financial barriers to sale/install and where/how used</li> <li>• Update all cooperative financing guides; publicize widely</li>   <li>• Leverage system retrofits efforts (such as Whole House) to advance energy efficient lighting</li>   <li>• Ongoing</li> </ul>	<ul style="list-style-type: none"> <li>• With RD&amp;D and policy advisors, reassess financial barriers to sale/install</li> <li>• Update all cooperative financing guides; publicize widely</li>   <li>• Ongoing</li>   <li>• Ongoing</li> </ul>
<p><b>3-4:</b> Introduce advanced lighting technologies, systems and best practices into the marketplace with progressive goals.</p>	<ul style="list-style-type: none"> <li>• Study product introductions from other industries to inform strategies for lighting technology introductions</li> <li>• Conduct a lighting transition/ intervention points study (segmented by building type); use results to accelerate best practice adoption</li> <li>• Research and propose business case for best practice lighting (including GHG offsets) to CFOs and key decision makers</li> </ul>	<ul style="list-style-type: none"> <li>• Continue to study, refine and promulgate best practices</li>   <li>• Develop reward/awareness for old products and large scale change outs</li>   <li>• Ongoing</li> </ul>	<ul style="list-style-type: none"> <li>• Continue to study, refine and promulgate best practices</li>   <li>• Ongoing</li>   <li>• Ongoing</li> </ul>

**Goal 4: Develop research, development and demonstration (RD&D) networks to create, test and deliver the lighting solutions needed to transform California's lighting market and achieve ZNE goals.**

Major advances in lighting systems and best practices are necessary by 2015 for California to achieve the Strategic Plan's goals. Research, development and demonstration (RD&D) efforts must address a wide range of technological issues (such as retrofitting lighting applications to integrated systems with smart controls and demand response capabilities) and include large scale, high-profile demonstration projects that showcase these solutions.

Given the global nature and fast pace of the lighting industry, it is vital that California uses its position as a leader and innovator to transform the international lighting market in order to meet the aggressive timelines identified herein.

To create an effective movement toward lighting market transformation, California needs a collaborative lighting RD&D approach that coordinates research and related activities with stakeholders to develop a lighting RD&D roadmap for California. Through an associated advisory body, the coordinated approach would create a network of collaborative partnerships among lighting industry market actors (in the public and private sectors) to develop, refine and improve statewide best practices. These efforts would focus on rapid market transformation, instead of slow, incremental technological advances.

Changing the state of the lighting industry will require significant cooperation among all market actors. For example, stakeholders overseeing publicly funded emerging technologies programs could seek partnerships with lighting industry peers to identify opportunities for rapid deployment of best practice solutions. These players would help to establish support and funding and participate in ongoing RD&D forums, workshops and other activities to disseminate lighting solutions and demonstrated outcomes. The PIER program has already undertaken noteworthy efforts in this area; Californians should continue to develop and expand upon these endeavors.

Activities could include researching reducing lighting power density and hours of use through smart integrated controls and other solutions that will help create improved best practices in the marketplace.

Demonstration projects are also a critical element of RD&D efforts to develop, assess and confirm field performance, identify improvements, prevent failures, create case studies and best practices.

Demonstration results would be integrated with the IOUs' Emerging Technologies programs and shared with the lighting industry at large using the CPUC web portal\* and other communications platforms.

*The CEC's Public Interest Energy Research (PIER) Program, California Institute for Energy and Environment\* and California Lighting Technology Center\* jointly demonstrate innovative interior and exterior lighting systems at sites throughout the state. Using a similar collaborative model, the RD&D strategies in this chapter will define best practices, develop the RD&D roadmap and demonstrate the lighting technologies and solutions needed to achieve California's ZNE goals.*

Strategies to develop a robust, integrated RD&D network include:

- **RD&D Infrastructure:** Establish and maintain a collaborative, multi-institutional statewide lighting RD&D approach.
- **Smart Technologies:** Develop smart lighting\* technologies, systems and solutions that are optimized for energy savings, demand response, renewable energy and human performance.
- **High-Profile Demonstrations:** Design creative, high-profile demonstrations of best practice lighting solutions that are scalable, targeted and leverage regional, statewide and national projects.

**Goal 4: Integrated RD&D Network**

<b>Implementation Plan and Timeline</b>			
<b>Strategies</b>	<b>Near Term 2010 – 2012</b>	<b>Mid Term 2013 – 2015</b>	<b>Long Term 2016 – 2020</b>
<p><b>4-1:</b> Establish and maintain a research-based collaborative, multi-institutional statewide lighting RD&amp;D approach.</p>	<ul style="list-style-type: none"> <li>Establish a lighting RD&amp;D advisory group with relevant subgroups to provide long-term guidance to California in the lighting efficiency and sustainability arenas</li> <li>Publish California's first statewide multi-institutional lighting RD&amp;D roadmap</li> <li>Establish an online resource (integrated with the CPUC web portal) to assist disseminating RD&amp;D solutions and demonstration outcomes</li> <li>Develop ongoing RD&amp;D forums and workshops to assist in disseminating solutions and demonstration outcomes</li> <li>Establish broad support and funding for RD&amp;D portfolio</li> </ul>	<ul style="list-style-type: none"> <li>Host ongoing quarterly roundtables, provide annual reporting on advisory's findings</li> <li>Conduct annual roundtables to refine and update roadmap</li> <li>Create initiatives that support/fund manufacturer partnerships' development</li> <li>Conduct ongoing RD&amp;D forums and workshops</li> <li>Pursue broad funding support for RD&amp;D activities</li> </ul>	<ul style="list-style-type: none"> <li>Host ongoing quarterly roundtables, provide annual reporting on advisory's findings</li> <li>Conduct annual roundtables to refine and update roadmap</li> <li>Ongoing</li> <li>Conduct ongoing RD&amp;D forums and workshops</li> <li>Ongoing</li> </ul>
<p><b>4-2:</b> Develop smart lighting technologies, systems and solutions that are optimized for energy savings, demand response, renewable energy and human performance.</p>	<ul style="list-style-type: none"> <li>Research and develop solutions that lead to a 25% reduction in lighting power density and hours of use through smart integrated controls</li> <li>Experiment with novel programs to launch new technologies which help create improved best practices in the marketplace</li> <li>Develop a research plan for exploring non-energy lighting performance, including economic, human factors, style, etc.</li> <li>Develop and use market intelligence on energy use patterns, best practices and trends and behaviors with industry partners</li> <li>Commission a study to assess best practices in RD&amp;D programs (inside and outside of the energy efficiency industry)</li> </ul>	<ul style="list-style-type: none"> <li>Target solutions that create a 50% reduction in lighting power density</li> <li>Continue development of new programs to launch new systems and technologies</li> <li>Ongoing</li> <li>Share findings with market (ongoing)</li> <li>Establish links to other efficiency programs and agencies</li> </ul>	<ul style="list-style-type: none"> <li>Extend power density reductions to 60% or greater</li> <li>Continue development of new programs for new systems and technologies</li> <li>Ongoing</li> <li>Share findings with market (ongoing)</li> <li>Establish links to other efficiency programs and agencies</li> </ul>

Implementation Plan and Timeline			
Strategies	Near Term 2010 – 2012	Mid Term 2013 – 2015	Long Term 2016 – 2020
<p><b>4-3:</b> Design creative, high-profile demonstrations of advanced lighting technologies that are scalable, targeted and leverage regional, statewide and national projects.</p>	<ul style="list-style-type: none"> <li>• Develop a standardized framework that identifies goals, objectives, field protocols and expected outcomes for demonstration projects</li> <li>• Establish a formal, universal process for data collection, analysis (evaluation and measurement) and technology handoff of RD&amp;D demonstration projects</li> <li>• Design collaborative demonstration programs that are highly visible, scalable, targeted and leverage other demonstration efforts</li> <li>• Establish formal feedback program that leverages the CPUC web portal to disseminate results and lessons learned from demonstration projects</li> </ul>	<ul style="list-style-type: none"> <li>• Modify framework based on a review of goals and outcomes</li> <li>• Ongoing</li> <li>• Launch integrated demonstration collaborative</li> <li>• Modify efforts based on industry feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Ongoing</li> <li>• Ongoing</li> <li>• Ongoing integrated demonstration collaborative</li> <li>• Ongoing</li> </ul>

## GLOSSARY

### **AB 811**

California Assembly Bill 811 (authored by Assembly member Lloyd Levine and signed by Governor Arnold Schwarzenegger on July 21, 2008), which authorizes California cities and counties to designate areas within which willing property owners could enter into contractual assessments to finance the installation of energy efficiency improvements and/or distributed renewable energy generation. For more information, visit [http://info.sen.ca.gov/pub/07-08/bill/asm/ab\\_0801-0850/ab\\_811\\_bill\\_20080721\\_chaptered.pdf](http://info.sen.ca.gov/pub/07-08/bill/asm/ab_0801-0850/ab_811_bill_20080721_chaptered.pdf).

### **AB 1109**

California Assembly Bill 1109; see “Huffman Bill”

### **Advanced Lighting Technologies**

Components and systems with improved performance attributes that contribute toward efficiency enhancement and best practices. Examples (in 2010) include specialty CFLs, LEDs, cold cathode and high-efficiency incandescents (HEI).

### **Air Resources Board (ARB)**

A part of the California Environmental Protection Agency that reports directly to the Governor's Office in the Executive Branch of California State Government. The ARB's mission is to promote and protect public health, welfare and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state.

### **Best Practice**

Coordinated technologies, systems and design approaches, which (through research and experience) demonstrate the ability to consistently achieve above standard results while avoiding negative environmental impacts. Best Practices change over time as improved components, technologies, systems and design approaches become available.

### **California Institute for Energy and Environment (CIEE)**

A branch of the University of California Energy Institute, CIEE is a partnership of energy agencies, utilities, building industry, non-profits and research entities designed to advance energy efficiency science and technology for the benefit of California, other energy consumers and the environment. For more information, visit CIEE's website at <http://uc-ciee.org>.

### **California Lighting Technology Center (CLTC)**

Established in 2003 at the University of California, Davis, the CLTC is an organization developed through a collaborative effort between the CEC, the California utilities, the U.S. Department of Energy (DOE) and the National Electrical Manufacturers Association (NEMA) to advance energy efficient lighting and daylighting technologies. For more information, visit the CLTC website at <http://cltc.ucdavis.edu>.

### **CPUC Web Portal**

The CPUC's Energy Efficiency Web Portal, is a website currently under development by the CPUC designed to serve as an organizing and information vehicle to achieve the California Energy Efficiency Strategic Plan vision.

### **Daylighting**

Building assemblies (such as use of windows, skylights, light tubes and reflective surfaces) designed to introduce daylight into a building for the purpose of illumination, view and to reduce a building's reliance on electric lighting.

### **Demand Response**

Mechanism for managing end user electricity consumption in response to energy supply conditions. A demand responsive system is one that can be controlled (either directly or remotely) to reduce electricity consumption during times of increased energy demand and/or constrained energy availability.

### **Federal Energy Policy Act**

A bill (Pub.L. 109-58) passed by the United States Congress and signed into law by President George W. Bush on August 8, 2005, which includes provisions for tax

incentives for energy efficient equipment, requires the DOE to research demand response and other elements. For more information, visit the Federal Energy Regulatory Commission website at <http://www.ferc.gov/legal/fed-sta/ene-pol-act.asp>.

**First Cost**

Immediate purchase and installation cost. First costs do not include lifecycle or long-term operating costs, which may result in long-term cost savings from increased efficiency, reduced maintenance and other factors.

**Green Teams**

A formal or informal group of people in a company who are passionate about environmental issues. The groups brainstorm solutions and promote ways in which their company's practices can become more environmentally sustainable, often creating sustainability plans and approaching management for funding to meet plans.

**Huffman Bill**

California Assembly Bill 1109 (authored by Assembly member Jared Huffman and signed by Governor Arnold Schwarzenegger on October 12, 2007), which prohibits the manufacturing for sale or the sale of certain general purpose lights that contain hazardous substances and requires the California Energy Commission to adopt energy efficiency standards for general purpose lights. For more information visit [http://www.leginfo.ca.gov/cgi-bin/postquery?bill\\_number=ab\\_1109&sess=CUR&house=B&author=huffman](http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_1109&sess=CUR&house=B&author=huffman).

**Integrated Systems**

Lighting systems that include components, assemblies and controls designed to work together effectively.

**Lifecycle Cost**

Cost of a component, technology, or system over its entire lifespan, including not just first costs but also operating, maintenance and disposal costs.

**Local governments**

Entities including cities, counties, special districts and school districts.

**Market Transformation**

Long-lasting, sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to the point where continuation of the same publicly-funded intervention is no longer appropriate in that specific market. Market transformation includes promoting one set of efficient technologies, processes or building design approaches until they are adopted into codes and standards (or otherwise substantially adopted by the market), while also moving forward to bring the next generation of even more efficient technologies, processes or design solutions to the market.<sup>17</sup>

**Pattern Book**

Prototype designs for energy efficient lighting suitable for typical building types. Information on lighting products and techniques enables the architect, interior designer, electrical contractor, building professional or do-it-yourself homeowner to design quality lighting for individual space types.

**Property-Assessed Clean Energy (PACE)**

A form of financing that creates municipal finance districts to provide loans to homeowners and businesses for energy-efficient retrofits and renewable energy system installations. Loans are repaid through an annual surcharge on property tax assessments. Governor Schwarzenegger signed the nation's first law allowing PACE financing in 2008.

**Public Interest Energy Research (PIER)**

Program created by the CEC to conduct public interest energy research that seeks to improve the quality of life for California citizens by providing environmentally sound, safe, reliable and affordable energy services and products. It includes the full range of research, development and demonstration activities that will advance science or technology not adequately provided by competitive and regulated markets. For more information, visit the PIER website at <http://www.pierminigrid.org/>.

**Reach Codes**

Codes that direct contractors to construct buildings significantly more energy efficient than required by conventional building codes.

**Simple Payback**

Amount of time required to recover an initial investment.

**Smart Lighting**

Lighting that is dynamically responsive to end user needs based on daylighting, occupancy, scheduling and demand response requirements.

**Standard Practice**

As opposed to best practices, standard practices include techniques, policies, methodologies, procedures, technologies and systems that are typically employed by practitioners and generally do not achieve optimal results (in terms of energy efficiency, demand-responsiveness, high quality, environmental sustainability, smart grid connectedness and integration with renewable energy generation sources). For lighting, standard practices may include efficiency “floors” required by building codes.

**Sustainable**

Describes a technique, policy, methodology, procedure, technology, or system designed or configured in such a way as to minimize (or entirely eliminate) negative impacts on natural ecosystems and public health.

**Title 20**

The Appliance Efficiency Regulations (California Code of Regulations, Title 20, Sections 1601 through 1608), which details current efficiency regulations for appliances sold or offered for sale in California, except those sold wholesale in California for final retail sale outside the state and those designed and sold exclusively for use in recreational vehicles or other mobile equipment. The standards are updated periodically to allow consideration and possible incorporation of new energy efficiency technologies and methods.

<http://www.energy.ca.gov/2006publications/CEC-400-2006-002/CEC-400-2006-002-REV2.PDF>.

**Title 24**

California's Energy Efficiency Standards for Residential and Nonresidential Buildings (California Code of Regulations, Title 24, Section 6), which contain the regulations that govern the construction of buildings in California. The standards are updated periodically to allow consideration and possible incorporation of new energy efficiency technologies and methods. On April 23, 2008, the CEC adopted the most recent standard and the Building Standards Commission approved them for publication on September 11, 2008. These standards will go into effect for all building permit applications submitted on or after January 1, 2010. <http://www.energy.ca.gov/title24/>.

**Research, Development and Demonstration**

A process incorporating the discovery of new knowledge and understandings using experimental methodology. This includes translational activities of applying research to the evolving of new systems and projects and activities wherein new products and approaches are tested to develop applications based performance data.

**Zero Net Energy**

For buildings, use of no more energy over the course of a year than can be generated onsite through renewable resources such as solar, wind, or geothermal power.

## LIST OF ACRONYMS

ARB	California Air Resources Board <a href="http://www.arb.ca.gov">www.arb.ca.gov</a>
CEC	California Energy Commission <a href="http://www.energy.ca.gov">www.energy.ca.gov</a>
CFL	Compact Fluorescent Lamp
CIEE	California Institute for Energy and Environment (CIEE) <a href="http://uc-ciee.org">uc-ciee.org</a>
CLTC	California Lighting Technology Center <a href="http://cltc.ucdavis.edu">cltc.ucdavis.edu</a>
CO <sub>2</sub>	Carbon Dioxide
CPUC	California Public Utilities Commission <a href="http://www.cpuc.ca.gov">www.cpuc.ca.gov</a>
DOE	U.S. Department of Energy <a href="http://www.energy.gov">www.energy.gov</a>
EM&V	Evaluation, Measurement and Verification
GHG	Greenhouse Gas
IOU	Investor-Owned Utility (includes PG&E, SCE, SCG and SDG&E)
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode (also used to describe lamps using LED technology)
LEED	Leadership in Energy and Environmental Design (green building rating system) <a href="http://www.usgbc.org/LEED">www.usgbc.org/LEED</a>
NEMA	National Electrical Manufacturers Association <a href="http://www.nema.org">www.nema.org</a>
PACE	Property-Assessed Clean Energy
PG&E	Pacific Gas & Electric Company <a href="http://www.pge.com">www.pge.com</a>
PIER	Public Interest Energy Research <a href="http://www.pierminigrid.org">www.pierminigrid.org</a>
RD&D	Research, Design and Demonstration
SCE	Southern California Edison Company <a href="http://www.sce.com">www.sce.com</a>
SCG	Southern California Gas Company <a href="http://www.socalgas.com">www.socalgas.com</a>
SDG&E	San Diego Gas & Electric Company <a href="http://www.sdge.com">www.sdge.com</a>
ZNE	Zero Net Energy

## APPENDIX A

Space Types	Best Practice Retrofits	Standard Practice Retrofits
<b>Commercial Office</b>	Task/Ambient lighting with occupancy and daylight controls with 73% energy savings or 0.5 Watts/sq ft	Retrofit of ambient lighting system with 37% energy savings or 1.1 Watts/sq ft
<b>Educational Classrooms</b>	Integrated Classroom Lighting System with occupancy controls with 65% energy savings or 0.7 Watts/sq ft	Recessed troffer fixtures with occupancy controls with 50% energy savings or 1.0 Watts/sq ft
<b>Residential Downlights</b>	High quality LEDs or SSL fixture system with 79% energy savings	Compact fluorescent (CFL) fixture system with 60% energy savings
<b>Commercial Downlights</b>	High quality LEDs or SSL fixture systems with 78% energy savings	Compact fluorescent (CFL) fixture system with 54% energy savings
<b>Exterior Lighting (e.g. Parking lot ,pathway, not including parking garages)</b>	Smart Bi-level lighting systems with occupancy and daylight controls with 40% energy savings	Standard lighting with photocell controls with 0% energy savings
<b>Interior HID Applications (e.g. retail and industrial)</b>	Electronic HID ballasts with 25% system energy savings or 0.75 Watts/sq ft	Magnetic HID ballasts with 0% energy savings or 1.0 Watts/sq ft

*Please Note: These best practice examples show the total technical savings potential and are primarily intended to illustrate the results from the using best practices versus standard practices over 10 years. Calculations are based on accepted estimates for total building stock, assumed hours of operations, demonstrations and verified savings results from both standard and best practice approaches. Detailed accounting including source and assumption data is in the 2010 Lighting Technology Overview.*

## ENDNOTES

---

<sup>1</sup> California Energy Commission. *California Energy Demand 2003-2013 Forecast: Staff Report*. Prepared in Support of the Electricity and Natural Gas Report under the Integrated Energy Policy Report Proceeding (02-IEP-01). August 2003.

<sup>2</sup> California Lighting Technology Center (CLTC). *2010 Lighting Technology Overview*. Prepared for the CPUC, 2010.

<sup>3</sup> KEMA Inc. *Final Evaluation Report: Upstream Lighting Program (Volume 1)*. Prepared for the CPUC Energy Division. February 8, 2010.

<sup>4</sup> California Lighting Technology Center. Preliminary results from ongoing CLTC study on Super CFLs. Prepared for the CPUC, 2009.

<sup>5</sup> California Lighting Technology Center. *2010 Lighting Technology Overview*.

<sup>6</sup> *ibid.*

<sup>7</sup> *ibid*, page 3.

<sup>8</sup> Gibbs, M. and J. Townsend. *The Role of Rebates in Market Transformation: Friend or Foe?* Published in the Proceedings of the ACEEE 2000 Summer Study on Energy Efficiency in Buildings, 6.121-6.132. Washington, D.C., 2000.

<sup>9</sup> CLTC. *2010 Lighting Technology Overview*. page 8.

<sup>10</sup> Pierce, S. *California Outdoor Lighting Baseline Assessment*. Prepared for the California Energy Commission, PIER Program. P500-03-082-A-18. 2003.

<sup>11</sup> Gauna, et al. "Developing Lighting Technologies: Integrated Office Lighting." PIER Final Report, California Energy Commission. May 2008.

<sup>12</sup> CLTC. *2010 Lighting Technology Overview*. page 4.

<sup>13</sup> California Public Utilities Commission, California Long-Term Energy Efficiency Strategic Plan, Section 2-Page 22; See also, Decision 09-09-047 (D.09-09-047) September 24, 2009, pgs. 137-138 (Available at: <http://docs.cpuc.ca.gov/proceedings/A0807021.htm#decisions>)

<sup>14</sup> Opinion Dynamics Corporation. *Ethnographic Research Findings*. Presented to the CPUC on August 25, 2009. Available at <http://www.cpuc.ca.gov/NR/rdonlyres/3D5AC333-D531-4734-AF9D-1A28AF7E5008/0/FinalEthnographicResearchPresentation.PDF>

<sup>15</sup> Rosenfeld, Arthur H. (Commissioner, California Energy Commission). "From the Lab to the Market to Standards The Role of California Energy Policy." Digital presentation at California Lighting Technology Center. CEC-999-2006-023. November 2006.

<sup>16</sup> KEMA Inc. *Final Evaluation Report: Upstream Lighting Program (Volume 1)*. Prepared for the CPUC Energy Division. February 8, 2010.

<sup>17</sup> California Public Utilities Commission, D.09-09-047.